River and Stream Biological Monitoring Program

Frequently Asked Questions

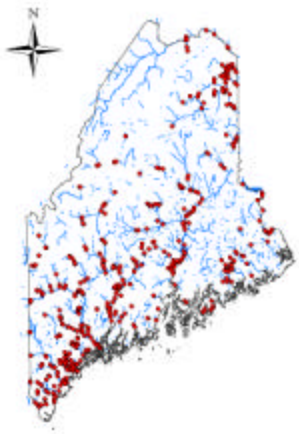
Sheepscot River in North Whitefield

DEP LW0561
December 2002

What is the Biological Monitoring Program?

The Biological Monitoring Program of the Maine Department of Environmental Protection (MDEP) assesses the health of rivers and streams by evaluating the composition of resident biological communities. The program has been sampling locations throughout Maine since 1983, and by late summer 2002 had established more than 650 monitoring stations on approximately 232 rivers and streams (Fig. 1). Data collected in accordance with Maine's biocriteria protocol are analyzed using statistical models, whose results estimate the association of a sample to four water quality classes defined by Maine's Water Classification Program. Findings of the Biological Monitoring Program are used to document existing conditions, identify problems, set water management goals, assess the progress of water resource management measures, and trigger needed remedial actions.

Fig. 1. Biological Monitoring Stations in Maine



What is the Water Classification Program?

The United States Clean Water Act requires that states protect and maintain the chemical, physical and biological integrity of the nation's waters (Appendix). In pursuit of this directive, the Maine State Legislature in 1986 created the Water Classification Program (Title 38 MRSA Art. 4-A) to improve the management of the State's waters (Appendix). The Legislature declared that it is the State's objective to restore and maintain the chemical, physical, and biological integrity of the State's waters and to preserve certain pristine State waters. The Legislature also recognized that it was unrealistic to assign the same environmental goals to all of the State's fresh surface waters. As a result, the Legislature adopted the following four Classes (Appendix and Table 1, below) of fresh surface waters, excluding great ponds:

- Class AA Waters. Class AA is the highest classification and is applied to waters that are outstanding natural resources which should be preserved because of the ecological, social, scenic, or recreational importance.
- Class A Waters. Class A is the second highest classification.
- Class B Waters. Class B is the third highest classification.
- Class C Waters. Class C is the fourth highest classification and establishes the State's minimum environmental goals.

The Legislature created water quality standards to establish the environmental goals (designated uses) for each of the Classes. For example, "Class A waters shall be of such quality that they are suitable for the designated uses of drinking water after disinfection; fishing; recreation in and on the water; industrial process and cooling water supply; hydroelectric power generation, except as prohibited under Title 12, section 403; and navigation; and as habitat for fish and other aquatic life. The habitat shall be characterized as natural." To further define the environmental goals, the Legislature established narrative and numeric criteria. For example, "the dissolved oxygen content of Class A waters shall not be less than 7 parts per million or 75% saturation, whichever is higher. The aquatic life and bacteria content of Class A waters shall be as naturally occurs."

In summary, the Legislature created the Water Classification Program to establish four classes with different levels of environmental protection (AA, A, B, and C). For each class, the Legislature defined the desired environmental goals (designated uses). The Legislature also established narrative and numeric criteria that must be met to attain the desired environmental goals. The MDEP stream biomonitoring protocol provides a statistically defensible and reproducible decision-making tool for making quantitative determinations about attainment of biological water quality standards.

What water quality criteria are currently used in Maine?

Maine's water quality standards specify different levels of water quality necessary to maintain designated uses (such as swimming or habitat for aquatic life). The standards currently have numeric criteria for dissolved oxygen and bacteria, and narrative criteria for habitat and aquatic life in rivers and streams (see Fig. 2 and Table 1). A waterbody must meet the requirements of all four criteria to be in attainment of its designated uses.

Fig. 2. Maine's Aquatic Life Management Classes

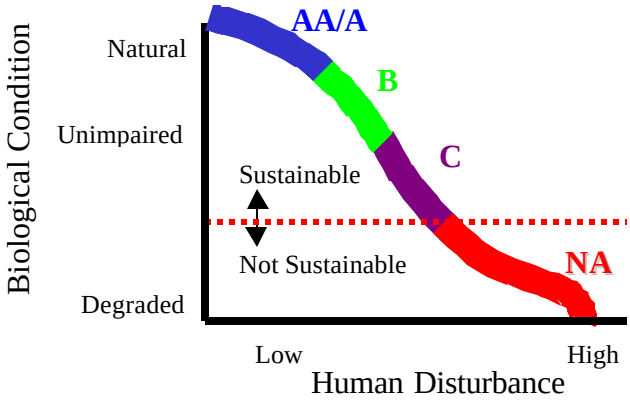


Table 1. Maine Water Quality Criteria for Classification of Fresh Surface Waters (38 MRSA §465)

	Dissolved Oxygen Numeric Criteria	Bacteria (*E. coli*) Numeric Criteria	Habitat Narrative Criteria	Aquatic Life (Biological) Narrative Criteria
Class AA	as naturally occurs	as naturally occurs	free flowing and natural	No direct discharge of pollutants; ***as naturally occurs***
Class A	7 ppm; 75% saturation	as naturally occurs	natural	***as naturally occurs***
Class B	7 ppm; 75% saturation	64/100 ml (g.m.*) or 427/100 ml (inst.*)	unimpaired	Discharges ***shall not cause adverse impact*** to aquatic life in that the receiving waters shall be of sufficient quality to ***support all aquatic species indigenous to the receiving water without detrimental changes to the resident biological community***.
Class C	5 ppm; 60% saturation	142/100 ml (g.m.*) or 949/100 ml (inst.*)	habitat for fish and other aquatic life	Discharges ***may cause some changes*** to aquatic life, provided that the receiving waters shall be of sufficient quality to ***support all species of fish indigenous to the receiving waters and maintain the structure and function of the resident biological community***.

* g.m., geometric mean; inst., instantaneous level

What are biocriteria?

Biological criteria (biocriteria) quantitatively define the desired goals for maintaining aquatic life for each river and stream classification (i.e., AA, A, B, or C). For each water quality classification, the biocriteria define the structure and function of the resident biological community. The State may choose to measure any of several assemblages as an assessment of the health of the aquatic life. Maine's narrative aquatic life standard is broad enough to encompass any plants or animals which live in fresh water for at least part of their life cycle, including fish, amphibians, mussels, crustaceans, and insects. Maine's actual protocol for numeric biocriteria is designed to measure the response of benthic macroinvertebrates to human influences. Macroinvertebrates are animals without back bones that can be seen with the naked eye and live on the bottom of rivers and streams (e.g., mayflies, stoneflies, crayfish, clams).

Who assigns statutory classes to rivers and streams, and on what factors are assignments based?
Statutory classes for rivers and streams are assigned by the Legislature at least once every three years. The Maine Board of Environmental Protection, with input from the MDEP and public hearings, recommends an appropriate water quality classification based on ecological, social, scenic, or recreational importance and on existing uses (e.g., for preservation of aquatic life, drinking water, recreation, industrial process, navigation).

How does Maine's biocriteria protocol work?
The MDEP manual 'Methods for Biological Sampling and Analysis of Maine's Rivers and Streams' (Davies & Tsomides, 2002) provides a full account of sampling, laboratory, and analytical methods. Briefly, the following approaches are applied:

Sampling methods: Samples of benthic macroinvertebrate communities are collected in rock bags (or baskets or cones) from flowing streams. At least three substrate samplers are exposed in the waterbody for 28 days during the late summer, low flow period (July 1 to September 30). The MDEP usually conducts sampling, but others may also perform monitoring to determine attainment of classification if done according to a quality assurance plan.


Rock bag


Caddis flies

Laboratory methods: Samples are retrieved, sorted, and stored for identification by a professional freshwater macroinvertebrate taxonomist. Organisms are identified to species whenever possible or otherwise to the lowest taxonomic level possible.

Analytical methods: If a sample satisfies the minimum data requirements (total mean abundance of at least 50 individuals; generic richness for 3 replicate samplers of at least 15), data are entered into the MDEP's computer software for further analysis through the numeric criteria statistical model. The model is able to take large amounts of information generated from a biological sample, describe which variables appear to be most significant in the classification decisions, and provide a mathematical summary that integrates the information. The model produces scores from 0 to 1 that indicate the likelihood that a sample will attain each water quality class.

What was the basis for the statistical models used in the biocriteria protocol?
Back in the late 1980's, the MDEP set the numeric biocriteria goals for each water quality class by having biologists evaluate the benthic data for 144 samples and assign each sample an aquatic life attainment classification (A, B, C, or non-attainment) based on the degree to which the sampled community conformed to one of the aquatic life standards articulated in the narrative aquatic life standards in Maine's statute. The samples evaluated represented 300 distinct taxonomic units and 70,000 organisms collected from rivers, streams, and riverine impoundments. Those data and their classification assignments were used as the baseline for construction of the predictive statistical model that would be used to evaluate future macroinvertebrate samples for water quality classification attainment. Throughout the development process, the MDEP also submitted the technical details of the biocriteria protocol to extensive review by the scientific community, nationwide, via oral, technical presentations and peer-reviewed journal articles (Courtemanch 1984, 1995, Courtemanch and Davies 1988, Courtemanch et al. 1989, Davies et al. 1991, 1995). The original model was used from 1992 through 1999 when the model was recalibrated with an additional 229 sampling events. The

recalibration resulted in relatively minor changes to the structure of the original model, involving simplification of the structure of two of the sub-models, the elimination of two poorly performing variables, and changes in model coefficients to account for the new data.

Does the model account for natural variation in stream characteristics and biota?
The original dataset from which the model was constructed included 120 samples from minimally disturbed locations throughout the State. All samples conformed to habitat restrictions cited in the Methods Manual and all were collected during late summer, representing the annual high temperature and low flow conditions. They do not represent the entire universe of natural variability in the State, but they are representative of the majority of river and stream habitat types of management concern in Maine. In addition to the 120 minimally disturbed samples, the model-building dataset included other sampling events from small streams to large rivers and from depths of less than 1 foot to over 20 feet.

Why biological monitoring in addition to physical/chemical monitoring?
Traditional physical or chemical measures of water quality, such as levels of dissolved oxygen or concentrations of toxic contaminants in water, are indirect ways to evaluate the health of a waterbody. They allow one to draw inferences concerning expected effects on aquatic life but do not look directly at biological responses in the stream. Furthermore, monitoring of physical or chemical parameters only provides a snapshot in time - it only reveals the condition at the time the sample was taken but does not tell us anything about prevailing conditions.

In contrast, the diversity and composition of a stream's macroinvertebrate community is a direct measurement of the health of the aquatic life. Organisms not only integrate the full range of environmental influences (chemical, physical, and biological), but complete their life cycles in the water and are thus continuous monitors of environmental quality. Streams that are minimally disturbed by human activities typically have many different kinds of macroinvertebrates and a high diversity of sensitive macroinvertebrates that are intolerant to human influences. Streams that are highly degraded tend to have very low diversity and are dominated by species that can tolerate those conditions. Over the years, Maine's biomonitoring program has documented dramatic recoveries of biotic communities following improved water resource management.

What is the reason for monitoring aquatic insects and other invertebrates?
The MDEP chose to monitor aquatic invertebrates for a variety of reasons:

- invertebrates have a wide range of pollutant tolerances among the various species so the make-up of invertebrate communities changes depending on the type and severity of pollution or other stressors in the stream;
- invertebrates have diverse feeding and energy use strategies and thus the ability to provide information about disturbances in use of energy resources throughout the ecosystem;
- invertebrates are easy to collect using accepted and well-established sampling and analysis procedures;
- some form of benthic macroinvertebrate life can be found in all but the most severely polluted or disturbed habitats, unlike fish which may be absent due to natural causes like obstructions to passage;


Pollution-intolerant stonefly

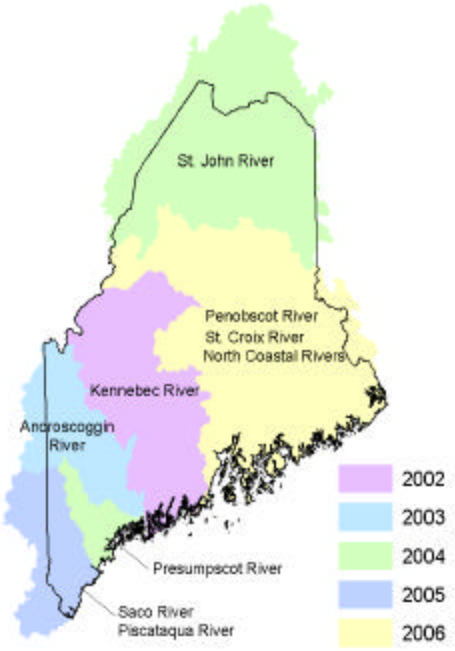

Pollution-tolerant leech

- compared to fish, invertebrates have limited mobility and are thus less able to avoid the effects of pollutants with the result that they integrate the impacts of water quality over time;
- compared to other parts of the country, for example Midwestern states, the indigenous fish community in Maine is not very diverse so that monitoring would be limited to just a few species; with invertebrates on the other hand, hundreds of species are available for monitoring.

How does the MDEP decide what waterbodies and locations to monitor?
For purposes of biological monitoring, the MDEP divided the state into five major river basins which are sampled on a 5-year rotational schedule (Fig. 3):

1. Androscoggin;
2. Kennebec and Mid-Coast;
3. Penobscot, St. Croix and North Coastal Rivers;
4. Piscataqua, Saco, and Southern Coast;
5. St. John and Presumpscot.

Figure 3: Rotating Basin Sampling Schedule



The decision to monitor specific locations on a waterbody can be based on a variety of factors such as:

- prior knowledge of existing activities that could have a detrimental effect on a waterbody: sampling seeks to detect actual impacts on biological communities;
- knowledge of future potential threats to a waterbody: sampling can be done to collect baseline data before, for example, development occurs or a discharge is licensed; follow-up sampling can determine the effect, if any, on the biological community by said development or discharge;
- requirement/desire to monitor the effects of remediation activities or water quality management changes;
- desire to expand coverage of the monitoring program and to more fully document natural variability.

Are definitions available for the technical terms used in the biological monitoring program?
Yes, terms are defined both in Maine's Water Classification Program (§ 465-C of Title 38 MRSA Art. 4-A) and in 'Classification Attainment Evaluation Using Biological Criteria for Rivers and Streams' (Section 1 of Chapter 579, the 'Biocriteria Rules', which are scheduled for promulgation in the fall of 2002). Terms defined include for example 'community structure' and 'community function', 'natural' and ''impaired', 'aquatic life', 'ecological attribute', and 'quality assurance plan'.

What are the guidelines for the MDEP's use of professional judgment?
The Biocriteria Rules provide for the use of best professional judgment (BPJ) in certain, clearly defined, situations, for example where sampling procedures or minimum provisions do not conform to the requirements of the Rules. Best professional judgment may also be applied where confounding factors exist or where it can be shown that there is a preponderance of evidence that an adjustment to the outcome of the statistical model is warranted.

What happens if a waterbody is found to be below its assigned statutory class?
If the sample is found to be appropriate for analysis and if BPJ does not indicate that the model outcome may need to be adjusted, the stream reach will be determined to be in non-attainment of its statutory class. In some cases this decision is clear cut, while in other cases it may be deemed prudent to repeat the sampling the following season to confirm the outcome. Once the decision of non-attainment is made, a number of actions are required:

- other programs within the MDEP such as Licensing or Land Use Regulation are notified that water quality management changes are needed;
- the stream reach is listed on the federally required 303d list of impaired waterbodies;
- a TMDL (total maximum daily load) plan for certain pollutants must be developed.

What happens if a waterbody is found to attain a classification higher than its assigned statutory class?
A sampling outcome that attains an aquatic life classification higher than the classification assigned to the waterbody is subject to the statutory provisions for antidegradation, meaning if the finding is confirmed under critical (worst-case) water quality conditions, those higher aquatic life conditions must be maintained. The MDEP will:

- confirm the finding by resampling;
- confirm that the higher aquatic life quality exists even at maximum allowed pollutant loads and worst case conditions: if so, those higher aquatic life conditions must be maintained;
- if other standards (dissolved oxygen, bacteria, habitat) are also attaining the next higher class, the MDEP may propose the waterbody for a classification upgrade at the next triennial water quality standards review.

List of References:

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Davies S.P. & Tsomides L., 2002. Methods for Biological Sampling and Analysis of Maine's Rivers and Streams. MDEP (DEP LW0387-B2002).

For additional information, please visit the website of the MDEP Biological Monitoring Program at: www.state.me.us/dep/blwq/docmonitoring/biomonitoring

Appendix

The Clean Water Act and Its Implementation

Federal Law: Protect chemical, physical, biological integrity of water bodies

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State Law: Specifies levels of biological condition to be achieved by water bodies according to a **classification** system

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Statutory Definitions: Identify attributes and characteristics used in defining levels of biological condition

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Biocriteria Rule: Specifies protocols for data analysis, and decision pathways, to be used to determine attainment of aquatic life class for rivers and streams

"classification"

Scores from statistical model estimate association of a sample to water quality classes

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Class A Class B Class C NA

⇩ Biological Community: ⇩

Natural ⟹ Degraded